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COMPUTER ASSISTED INSTRUCTION IN THE U. S. ARMED FORCES

James M. Mutter

COMPUTER ASSISTED INSTRUCTION IN THE U.S. ARMED FORCES

By

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Bachelor of Business Administration

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ACKNOWLEDGEMENT

It is obvious from the general scope of this paper (as indicated in the table of contents) that the material presented could not have been obtained without the assistance of several congenial, helpful, interested, and sometimes prodding allies. The sustained patience of my wife, Catherine Farrar; the probing nature and expert guidance of my director, Dr. Walton E. Smith; and the frequent and unselfish offering of their time by those professionals who permitted me to interview them are herewith sincerely and thankfully acknowledged.

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CHAPTER I

Anyone casually acquainted with the military and industrial complexes of the United States of America can not avoid noting the many applications of computers in those areas. It is difficult to give a brief listing of the uses of computers without risking gross over-simplication of the vast scope of their applications. They have been successfully employed for such diverse functions as scientific laboratory specimen analysis and interpretation; assembly and production line control; logistics management; weapons systems fire control; and optimum use resource scheduling for fields ranging from dating services to the control of power plant generation equipment. As computer systems gained greater computational speeds and decreased data retrieval times, they were tasked with performing jobs of even greater complexities than those just indicated. Examples of these jobs include the military's computer-oriented command, control, and communications systems; industry's management control and information systems; and the highly sophisticated precision control of National Aeronautics and Space Administration vehicles. For all practical purposes, a listing of computer applications to problem solving and control functions is inexhaustible.

It has now become very apparent that the computer has not gone unnoticed in that system which is singly responsible for supplying the basic requisite skills needed by the men and women of this Nation--the institutional education system. This study is about the application of computers to education, particularly in the military. The widespread applications of computers in non-educational projects gives some inkling as to the potential span of impact which computers may someday have on the extremely complex field of education. The use of the computer in education is known as computer assisted instruction and is identified by the letters, CAI (no phonetic word is formed, the letters are pronounced separately). While cognizance of the potential pitfalls of CAI are recognized, it is not the intent of this paper to discuss psychological or social implications which may be associated with mass use of CAI. It is sufficient here to state that computers, for the foreseeable future, will remain electronic tools with capabilities for doing great educational harm or good. This harm or good could be amplified rapidly and significantly depending on the scope of the application of computers in education. Only through highly refined, well managed CAI programs with consistent, critical evaluation and analysis will CAI avoid undesirable side effects. Proper evolution of CAI will help us achieve

progressively higher levels of educational sophistication and effectiveness.[1]

The military services have constantly tried new methods of instruction in an effort to enhance proficiency, improve retention and to reduce training costs. They, like the general public-education system, have not found movies, television, tapes and teaching machines as practical long term substitutes for human instructors. But the computer may be an answer to improving student-teacher ratios, reducing training times to acceptable levels of proficiency, and modifying the traditional tutorial method of teaching to the median level of intelligence of the class.

Statement of the Research Question

A great deal of this thesis is constructed around a discussion of civilian CAI progress in educational institutions. This technique is necessary because of the very limited work done with CAI, in general, in the Nation. Military involvement to any extent has been only in the fairly recent past.

An analysis of what has transpired in the field of automated teaching and to what degree of success is undertaken to arrive at a conclusion regarding the following basic question: Has CAI sufficiently evolved to risk extensive commitment of military training funds for this type of instruction?

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[1] Felix F. Kopstein, "Why CAI Must Fail!" Educational Technology, March, 1970, p. 53. (This article is written in a sarcastic vein.)

Scope and Organization of the Study

The ability of each individual to enhance his technical knowledge at his own pace has been recognized and has been the subject of many varied educational approaches, involving new teaching/learning techniques. It is significant, however, that through CAI the student-teacher relationship can "cycle back" to the oft-cited ideal Socratic approach to the learning of basic manipulative skills--one instructor for one student.[2] Accordingly, several subsidiary areas must be investigated to determine if large scale CAI implementation is feasible for the armed services. One such area is CAI evolution, i.e., what have been the major electro-mechanical evolutionary steps which have taken place and have lead to CAI? This subject as well as some of the basic criteria and characteristics which should be present for CAI consideration are discussed in Chapter II.

Chapter III expands the scope of the study to include investigation of CAI use and acceptability in the civilian world, as well as in our military forces. That chapter will therefore not only present current and proposed CAI applications

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[2] Some mass-media producers and users cite the economic advantages to scale with minimum instructor/maximum student mass instruction relationships; however, television, training "aids," video-tape, and movies remain, for the most part, passive instructional devices. It remains however that we have not been able to satisfactorily and economically train masses of people on a one-to-one student/teacher ratio.

but will also summarize data results which have been indicated in the readings undertaken in this effort.

In Chapter IV a discussion relative to the requirements for CAI will be presented--a few comments concerning instructional objections (in general) and some specifics on CAI capabilities and requirements will be made. It has been stated that until recently, conventional schooling techniques concerning the instruction of large groups of people had not significantly altered since the economics of instruction versus the quality of output entered the education arena. That consideration of economics still prevails and remains one valid analysis of an educational system's worth.[3] Any time costs are discussed, a veritable Pandora's box of "cost incurrance" qualifiers can be conjured up. This study accepts the data offered by today's military and educational CAI specialists as defensible. Chapter IV will also briefly touch on some of the hardware, software and personnel problems inherent to CAI implementation.

In the concluding Chapter, V, the author presents his decision as to the feasibility of military CAI, and offers some caveats concerning training. He also suggests some areas for consideration relative to a possible obligation to the general public that the military has not undertaken to any great extent--but which could enhance its own survivability and training costs.

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[3] Cornelius F. Butler, Dean Jamison, and Patrick Suppes, "Estimated Costs of CAI for Compensatory Education in Urban Areas," Educational Technology, September, 1970, pp. 48-49.

This paper, while objective, is non-technical in nature and makes no attempt to treat the computer system as more than a tool which is available for use by educators. As mentioned earlier this study, analysis of sociological or psychological implications of the mass use of CAI will not be undertaken.[4] All these problems are beyond the intent of the study; and in fact, at least one successful doctoral dissertation has been written on the psychological implications of CAI.[5]

Purpose and Utility of the Study

Throughout history one thing stands evident--technical progress is a result of the application of and improvement upon previously learned information and skills.

It has been a constant challenge to adequately train the thousands of personnel who rotate through the military services. These men must be given at least a rudimentary background in many, many areas before they can be considered qualified to be entrusted with the capability to interact in an organization having the complexity of any of our services. This training is a time-consuming, costly, sometimes extremely repetitive process. To a large extent the survival of today's technical military organization is contingent upon the abilities of its

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[4] _Supra_, p. 2.

[5] At the University of Texas, Austin, Texas, by Robert Gerry, LTCOL, USAF, Instructional Technology Staff Officer, personal interview held in Washington, D.C., during September, 1971.

young enlisted personnel to perform operations and maintenance functions successfully. Training, repetition and experience appear to be the only way to impart this ability.

CAI has been in an experimental stage for over a decade. The U.S. Government is financing civilian CAI experimentation and all the military services are investigating the potential of CAI. At this point in time no decisive commitments to plunge fully into the computer pool for training have been made in the military, although several experimental programs have been undertaken in the last five years.

As is suggested by the comments in the previous section, this study undertakes to survey CAI to arrive at some conclusions concerning its applications in military training. The author has worked in training in both the military and civilian worlds for approximately seven years, and has had considerable interchange concerning U.S. Marine Corps and Army CAI plans. This study will be provided CAI personnel in the Headquarters elements of those services (as requested by them) for their consideration of its findings and conclusions.

Research Methods Utilized and Method of Analysis

Except for the information obtained from the several interviews which were conducted during this study, data utilized were from secondary sources. These secondary sources included books and both published and unpublished reports. Several CAI

conference proceedings were also reviewed and, of course, periodical literature was surveyed and extracted. The National Educational Association, Academy for Education Advancement, and the Office of Education (of the Department of Health Education and Welfare) made available several publications which do not otherwise exist in local military or civilian libraries.

Because of the current "fence-riding" status of the services concerning massive CAI commitments, many of the military reports are still unofficial, and some contain only "working-level" information; however, this study presents no information from those reports which is of a classified or proprietary nature.

The method of analysis most utilized herein is deductive and from those sources cited. Elements of inductive reasoning are obvious in the recommendations made concerning overall service policy for CAI in the immediate future inasmuch as these conclusions are made from the study of the very few service cases available.

CHAPTER II

WHERE DID IT ALL START?

Time and time again we are confronted with the realization that what appears to be genuine originality is in truth an improvement upon or modification of the efforts of previous man. How in fact could it be otherwise?

Teaching Machine Evolution: A Delimited Review

By 1926, Sidney L. Pressey (at Ohio State University) had become quite concerned about the many routine and burdensome clerical and administrative tasks that educators were forced to accomplish simply from the necessity to discover the correctness of their students' works. He also felt that one of the most inefficient large scale undertakings of the day was the current methodology of the education system--it simply had no labor saving mechanisms.[1] He felt this was due to the fact that teachers were relatively inexpensive to hire and there was therefore little incentive towards innovation concerning cost saving devices. (In fact a much more recent writer

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[1] Sidney L. Pressey, "Educational Research and Statistics," School and Society, March 20, 1926, p. 376.

points out that conventional educational is still labor intensive.)[2] Pressey invented and built a teaching "apparatus" which could efficiently teach informational and drill materials, score tests and which could be made to restrict the instructional progress until a correct response was made to the question posed.[3] This simple but ingenious device was no larger than a portable typewriter and was essentially a "memory drum" (not unlike music box construction) which could be made to remain locked until the key corresponding to the correct answer on a quiz was depressed.[4] The device could be altered to permit mechanism advancement and recording of the chosen response without requiring that the response be necessarily correct. The device could therefore be used for testing as well as teaching. Pressey's machine was also used in an external reinforcement mode by dispensing candy or favors to small children when they depressed the correct response key.[5] Pressey believed that use of this device could save several hours of a teacher's time. He estimated that approximately 1,000 "off-duty" hours which were being spent in grading and recording students' tests could be saved each school year. He also stated that, if used

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[2] Robert J. Seidel, "Review of the Status of Project Impact," (paper presented at the Continental Army Command, (U.S.) Training Workshop held at Fort Gordon, Georgia, on October 5-7, 1971), p. 3.

[3] Pressey, "Educational Research and Statistics," p. 374.

[4] Ibid., p. 375.

[5] Ibid., p. 374.

in the instruction mode, the device could free the teacher from the boredom of drill and practice sessions and would permit her more time and opportunity to teach and otherwise develop her students.[6]

Pressey's device did not gain widespread use. B. F. Skinner attributes this to two specific causes. These causes were, first, that cultural inertia prevented their adoption, i.e., the educational world simply was not ready for teaching machines.[7] A second reason given for their lack of popularity was that Pressey's machine was not fully developed to the point of providing instruction. As used, the device did not really teach--it primarily reinforced responses to tests and this could only take place after learning had taken place elsewhere. (Skinner does concur that insofar as a reinforcement existed, some teaching did take place but at a low level.)[8]

Skinner was also dissatisfied with the traditional methods of instruction being used in our schools. By the early 1950's he had developed and presented his linear learning theory. Skinner felt that the student should be exposed to new fields in a manner such that no errors would be made in his responses. As Ofiesh implies, Skinner felt learning should be effortless but not thoughtless. Instruction is best structured if the student immediately knows whether or not he is correct in his

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[6] Ibid., p. 376.

[7] B. F. Skinner, "Teaching Machines," Science, October 24, 1958, p. 969.

[8] Ibid.

assumptions or knowledge about information presented to him at that point in time.[9] This technique is found not only in teaching machines but also in "programmed textbooks."[10]

Skinner felt that small frames of information should be presented to the learner and that at the end of each information frame there should be a question stimulus. The student's response must be correct or the machine should not advance (much like Pressey's machine) and the device had to be designed not only to test but also to present information--to replace the traditional teacher for certain subject areas. The machine does not teach of course, it merely presents data. Skinner seemed to prefer machines which had built into them a method of identifying those questions to which the learner incorrectly responded as well as those to which he had correctly responded. The machine should then again present those questions incorrectly answered by the machine user after he had completed the total information segment or subject subset on which he was working.[11] In this manner the student was mentally reinforced in those areas in which he had originally erred.

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[9] Gabriel D. Ofiesh, Programmed Instruction: A Guide for Management, (Chicago: American Management Association, Inc., 1965, pp. 37-38.

[10] Henry M. Berry, "A Historical and Critical Study to Determine the Feasibility of Expanded Use of Automated Instruction in the Naval Training Situation," (unpublished M.S. Thesis, U.S. Naval Post Graduate School, Monterey, California, 1965), pp. 4 and 9.

[11] Skinner, "Teaching Machines," pp. 970-971.

In 1958 Skinner compared teaching machines to private tutors as follows:[12]

1. There was a constant interchange between the program and the learner which demanded that the learner be always alert.

2. The machine would not advance until the response was correct; therefore, there was no chance that the student misunderstood what the correct answer was.

3. The machine would not rush the student--he would get information when he was prepared to receive it.

4. The machine, like the tutor, would help the learner arrive at a correct answer by presentation of an orderly constructed program.

5. The machine would reinforce the learner's understanding by providing immediate feedback to the response made by the student.

Skinner's ideas about linear presentation techniques were not universally accepted even by those who would at least accept the idea of non-human teaching devices. Another very popular technique, "branching," was developed by Norman A. Crowder. He felt that Skinner had made as serious an error in his linear programming method as Skinner felt Pressey had made in his device utilization. Crowder felt Skinner was in error because Skinner's method simply required a correct response for course progress. The student could keep guessing until he

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[12] _Ibid_., p. 971. A similar list of advantages very closely related to these can be found in an article by Nancy Larrick, "Teaching Machines: A Progress Report," _Library Journal_, Vol. 19, No. 1, (Spring, 1971), 1651-52.

made the correct response and was then permitted to continue. This method did not inform the learner why, if he made an incorrect choice, that choice was necessarily wrong.

Crowder called his technique "automatic tutoring."[13] It has also been known as a "branching," "intrinsic programming," or "scrambled" technique.[14] The essential difference between Skinner and Crowder was not in the leading and detail techniques each used, or the method of thorough investigation and testing of data before it was released as a program of instruction. The big difference was that Crowder's program would actually inform the learner exactly what was wrong with his choice if he chose an incorrect answer. The explanation might also recommend remedial action or study to correct the learner's misconceptions at that point. Crowder felt this communication interaction made his technique much more responsive and valuable than Skinner's simple conditioning method (i.e., a method whereby one was simply "wrong" until he chose the correct response).[15]

Many devices patterned after both the linear and branching methods were developed. One thing which aided what turned out to be a very rapid influx of teaching machines in the 1960's

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[13] Eugene Galanter, ed., Automatic Teaching: The State of the Art, (New York: John Wiley and Sons, Inc., 1959), p. 109.

[14] Ibid., p. 110.

[15] Ibid., pp. 112-16.

was the acute shortage of qualified teachers. It was stated that there were 195,000 too few teachers in 1960 and that to meet the requirement for the 1970's at least 30 per cent of all college graduates of the 1960's would have to elect to enter the teaching profession.[16] This proved the need for expansion of both mass and individualized methods of instruction. In the decade of the mid-1950's through the mid-1960's the use of both mass media techniques (such as movies and television) and individualized techniques (such as teaching machines and programmed texts) were greatly expanded over their previous use in industry, the armed services, and education.[17]

Industry responded to the opportunity to market another product. Unfortunately there was frequently too little time taken in the preparation of materials and virtually no standardization of materials, programs or machines was undertaken. Offerings ranged from 35mm film strips to microfilm "miniature" microfilm to simple single sheet or rolled paper presentations. Machine interchangeability and program compatibility was non-existent.[18] By 1962 over 40 different devices

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[16] Wilbur L. Ross, et al. Teaching Machines: Industry Survey and Buyers Guide, (New York: The Center for Programmed Instruction, Inc., 1962), pp. 1-3.

[17] Ibid., pp. 6-11. See also Ofiesh, Programmed Instruction, "Case Histories," pp. 165-401; See also Robert G. Smith, Jr., "Research Problems Related to the Implementation of Programmed Instruction, (report reprint presented in Collected Papers Prepared Under Work Unit TEXTRUCT Methods of Instruction In Technical Training, Human Resources Research Organization, Alexandria, Virginia, report No. 34-70, December, 1970), pp. 74-77.

[18] Edward B. Fry, Teaching Machines and Programmed Instruction: An Introduction, (New York: McGraw-Hill Book Company, Inc., 1963), pp. 17-19.

had been patented.[19] The problems of incompatibility and the fact that the early machines were no better than their much less expensive programmed text counterparts led to the demise of many companies and educators who invested in teaching machines. The problem was serious enough that the American Educational Research Association, the American Psychological Association, and the Department of Audio-Visual Instruction (now the Division of Educational Technology) of the National Education Association, issued a joint statement on teaching machines, their functions, and the necessity for thorough investigation of capabilities before purchase.[20]

But educators were not stopping in their quest for new instructional techniques because of a few mechanical problems or simply because some industrial programs were not of acceptable quality. As early as 1958 at least three areas of investigation of instructional methodology via the computer had been undertaken. These programs were:

1. The International Business Machines (IBM) Research Center program which was designed to teach binary arithmetic--and which included problem level of difficulty assignments to the learner which were based on the success experience to any point in the program.[21]

2. A System Development Corporation (SDC) program designed to use the computer as a control unit for a random access

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[20] "Functions of Teaching Machines," School and Society, (February 24, 1962), pp. 94-5.

[21] Galanter, Automatic Teaching, pp. 117-129.

projection device to provide a flexible teaching machine for research on Crowder's technique of branched instruction.[22]

3. A Bolt, Beranek and Newman Corporation study investigating computer applications to teaching in general.[23]

By 1961 five major projects with computers were reported by John E. Coulson, including one which permitted simultaneous multiple student access from separate student terminals to the computer-instructor.[24] By 1963 it was estimated that approximately 60 different CAI projects and course materials were in being; and at least one school, the University of Illinois, was using a CAI course for regular credit instruction.[25]

The most recent study which indicates the magnitude of CAI in use is that by Karl L. Zinn. This study lists over 200 projects and offices concerned with CAI and over 40 different CAI languages and dialects.[26]

Obviously, CAI has grown every bit as rapidly as did programmed instruction and teaching machines. Programmed instruction, even to those not intimately related with education

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[22] Karl L. Zinn, An Evaluative Review of Uses of Computers in Instruction, (U.S Department of Health Education and Welfare, December, 1970), Sec. I-3, p. 1.

[23] Ibid.

[24] John E. Coulson, ed., Programmed Learning and Computer Based Instruction, (New York: John Wiley and Sons, Inc., 1961), pp. 171, 191, 205, 217 and 240.

[25] Zinn, An Evaluative Review, Sec. I-3, p. 2.

[26] Ibid., Sec. I-3, p. 4, and Appendix B. (It should be pointed out that there is a current effort to update Zinn's work, according to Kevin F. Arundel, Education Specialist, Office of Education, Department of Health Education and Welfare, Washington, D.C., interview held during December, 1971.)

in the United States is very much on the decline while CAI innovation and acceptance is continuing on the upswing.[27]

Does this movement sound familiar--is CAI also fraught with the distrust, haste and inaccuracy of early programmed instruction? It does not really appear to be so. Although evolution is being reviewed here, a slight digression seems appropriate. Researchers and staffs are very cautious about implementing CAI. Of the 200 projects indicated earlier, only about 40 are full course instructional programs (although there are estimated to be over 1,000 samples of curriculum materials).[28] Approximately 60 per cent of those languages listed by Zinn were education center, vise industry-commercial, related.[29] This appears to be a clear indication of educator faith and commitment to the proper use and growth of the potential power of CAI. Probably the most dramatic and expansive example of tutorial CAI in use is at the University of Illinois;[30] although New York City has a very large drill and practice CAI operation.[31]

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[27] Hans-Peter Frei, "Study Trip to the USA (Summer/Fall 1970)," (an unpublished translation of a field trip concerning programmed and computer assisted instruction by the Swiss Federal Institute of Technology, Zurich, Switzerland, November, 1970), p. 5.

[28] Zinn, An Evaluative Review, Sec. I-3, p. 4.

[29] Ibid., pp. 5-7.

[30] First Regional Seminar of the National Security Industrial Association(NSIA), Application of Computers to Training (ACT), (held at U.S. Naval Training Center, San Diego, California on April 14, 1971), pp. XXIX-1 and 2.

[31] Cornelius F. Butler, "CAI in New York City: Report on the First Years Operations," Educational Technology, October, 1969, pp. 84-87.

The Illinois complex has grown from a single terminal, connected to the ILLIAC-I, to today's 20 graphic pictorial terminals operating on an interactive mode in over 10 different subject areas. Several CAI courses are accredited for graduation purposes at that university. Illinois is projecting plans for simultaneous, mixed course offerings using 4,000 student terminals over a large geographic area.[32]

The most successful tutorial CAI programs offer a computer-learner dialogue based on a complex branching taxonomy. This permits computer analysis of the response (or question) offered by the learner and presentation of a computer response appropriate to the level of understanding of the problem (or subject) possessed by the learner.[33]

Again the statement is appropriate--the machine does not teach, think, or create; it presents materials which are prepared, pre-analyzed and reviewed by man. It offers a method of, and an opportunity for, investigation and assistance in determining whether or not traditional instructional techniques are appropriate. Many have stated that this recent evolutionary step is long overdue--that traditional methods are not adequate and that educators and counselors have an opportunity and

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[32] First Regional Seminar of NSIA, ACT, p. XXIX-16.

[33] Diemut M. Heller, "Technology in Education," National Education Association, (Research Memo No. 1969-4, February, 1969), p. 3.

obligation to improve on their techniques which have been essentially unchanged since classroom utilization of the textbook.[34]

The computer has been hailed as the most obvious "next step" in solving the limitations of individualized adaptation of the programmed text and teaching machine.[35] Dr. Robert J. Seidel says it is time for education to take advantage of CAI, a capital, not labor intensive system,[36] and also a time for:

> " . . . those who are interested in studying the psychology of learning and instructional processes to bring together a basic science and an applied science into a single, unified, scientific discipline."[37]

Criteria for CAI Consideration

At this point some of the sematical problems relating to just what CAI is should be indicated. In his paper, currently being considered for publication, Alan B. Salisbury has listed twenty-two terms which authors have used frequently on a more or less indiscriminate basis in reference to the

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[34] Proceedings of the Learning, Retention and Transfer Technical Meetings, (sponsored by Honeywell, Inc., under contract to the Naval Training Devices Center, held at Winter Park, Florida, February 5-7, 1969), p. 64-66. See also Charles E. Silberman, "Technology is Knocking at the Schoolhouse Door," Fortune, August, 1966, p. 122.

[35] Keith A. Hall, "Computer Assisted Instruction: Problems and Performance," Phi Delta Kappan, June, 1971, p. 629.

[36] Seidel, "Review of Project Impact," p. 3.

[37] Robert J. Seidel, "Computers in Education: The Copernican Revolution in Education Systems," Computers and Automation, March, 1969, as reprinted by George Washington University, March, 1969, p. 5.

general subject area of CAI.[38] This author concurs with Major Salisbury's warnings and recognizes that precise definational requirements are necessary. Only then can users, suppliers and casual interested parties understand what a system defined as "such and such" can do, or can not do, as compared with another definationally identified system or operation. But sematical segregation will not better serve the purpose of this paper and as indicated earlier,[39] the use of a computer in any tutorial, instructive role is considered for purposes of this study, CAI.

No better, more direct, or simple statement of what appears to constitute adequate criteria for investigation of course applicability than that offered by the military "Shirtsleeve" committees on CAI has been found. That conference included no fewer than thirty educational and military conferees who are personally involved with CAI (at least 14 of whom held doctorates). A summary and interpretation of their recommendations concerning CAI selection criteria follows:[40]

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[38] Alan B. Salisbury, Major, U.S. Army, "Computer Support of Military Education and Training: A Study of Terminology." (Unpublished research paper prepared for the U.S. Army Signal Corps, April, 1971), pp. 2-3.

[39] Supra, Organization and Scope of the Study.

[40] Conference proceedings of the Joint Services CAI "Shirtsleeve" Conference, (Hardware, Software, Future and Initiation Committee Minutes, held at Fort Bliss, Texas, June 8-12, 1971), Software Committee Synopsis, pp. 1-3.

Student Loading Criteria

1. High repetitive annual student volume--CAI may reduce training times significantly.

2. High attrition rate--CAI is individualized and may well reduce attrition rates.

3. High instructor to student ratio--with CAI this ratio will approximate 1:1 without incurring additional instructor expenditures.

4. Heterogeneity of student population--the more varied the students' background, the more likely it is that the individualized instruction capability of CAI will help them.

Instruction and Location Expense Criteria

1. Course cost--compare costs of traditional versus CAI proposed modes of instruction.

2. Non-expendable equipment requirements--if CAI can simulate actual equipment useage many dollars in manpower and maintenance costs may be saved.

3. Stability of course content--those courses which change the least, if converted to CAI, will free more instructor time for other courses or instructional requirements.

4. Course commonality--if a similar course is taught at several sites CAI may drastically reduce instructional costs if all personnel receive one common CAI program.

5. Local attitude--CAI capabilities should be communicated to all education centers, then should be initiated at those sites or schools most desirous of using CAI.

6. Geographic considerations--it is most likely that there will be little impedence to CAI transmission over a broad geographic area from a central computer site, although communication transmission costs must be considered.

7. Aptitude--CAI course development must take cognizance of individual aptitude levels.

Course Characteristics Criteria

1. Course length--CAI has very frequently reduced training times by 20-30 per cent. In addition to saving time, the longer a course takes to complete the more it usually costs to conduct. A review of those courses taking the longest times to complete is in order.

2. Course complexity--generally speaking, the more complex and tutorial-oriented a course must be, the more difficult it will be to convert to CAI.

3. Cruciality of skill being produced--training for the most critical skills should be converted to CAI first. This permits the advantage of CAI's capability to produce consistent quality volume outputs in shorter periods of time and with less manpower expenditure.

4. Multi-skill level oriented--CAI will be more effective if it is designed to teach both the cognitive and procedural abilities required in the job for which the individual is being trained.

5. Course development level--courses which have been systems engineered and prepared on a basis of tractable instructional steps and learning objectives should be converted to CAI first; this is a basic requirement of CAI course preparation.

Intangible Criteria if CAI is Adopted

1. Scope of influence--because CAI is effective, if conversion of courses which are required knowledge for all organizational levels of personnel is undertaken, this exposure will insure a basic understanding of CAI applications potential at all levels.

2. Political considerations--CAI courses are expensive to develop and must be thoroughly tested before use. Adverse political reaction due to complete reworking of unsatisfactory courses is always a possibility; on the other hand, a highly successful skill-teaching CAI course for low intelligence level personnel may be politically rewarding.

Synopsis

It has been stated that in the military we should be most concerned with developing CAI courses for present courses

of instruction which have great student heterogeneity, low aptitude levels, high annual student volume and attrition rates, close instructor-student ratios, and use expensive training equipment or simulators.[41] Regardless of the other criteria selected for evaluation, or the conclusions developed, there is a general consensus that no conversion to CAI should be undertaken in the military unless it meets the criteria of being cost-effective. But it was also stated that there was little in the way of a base-line cost effectiveness model to objectively present CAI costs, " . . . (i.e., to support initiation, continuation or expansion of a CAI system) . . . [but that] cost effectiveness studies . . . by the Army (Fort Monmouth) and the Marines (MCB, 29 Palms, California) should serve as starting points."[42]

This chapter has presented a brief review of teaching machine evolution to date and has pinpointed criteria considerations for adaptation of courses to a CAI system.

The limited applications of simple teaching machines has precluded their use in large numbers although current models are considerably more effective. The problems of improving upon student/instructor ratios to teach manipulative skills is still evident, and is a problem found in military, industrial, and vocational schools as well as regular educational institutions.

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[41] CAI "Shirtsleeve" Conference, Software Committee Report Sec. II, pp. 2-3.

[42] Ibid., Initiating Operations Committee Report, pp. 4-5. ("MCB, 29 Palms" is an abbreviation for the words, "Marine Corps Base, Twenty-Nine Palms.")

Most individualized instruction is expensive and one of the major training problems is economical conversion of training dollars into useable personnel skills. CAI appears to be one of the most technically feasible methods of reducing training costs--it may be the most significantly different and satisfactory approach to the education of large groups of people since the mass distribution of books.

Satisfactory CAI is the economical integration of educational techniques and goals with the evolutionary improvements now available in computer programming and processing capabilities. To maximize the effectiveness of CAI, consideration must be given to proper implementation of the established principles concerning the psychology of learning.

CHAPTER III

PRESENT STATUS OF CAI IMPLEMENTATION

To list all the applications of CAI currently in progress or in use would serve little purpose--just to briefly discuss 15 current, representative projects took 62 pages in Zinn's Review.[1] Here, too, will be presented only some representative but specific CAI projects which are under way in the military and civilian arenas. It will be evident that this text does not deal with a wide range of legitimate uses of the computer in an educational institution. Ample evidence exists that frequently initial use of the computer in education is not in a computer-instructional role, but rather is in other areas; for example, administration, payroll, grading, inventory control, scheduling, research, and/or of course, computer and data processing courses.[2] One final word concerning the application of the computer in education before delving into specifics is in order. Cognizance is taken of the various facets of CAI teaching strategies or applications but examination and discussion of them by class is not undertaken (for example, computer assisted,

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[1] Zinn, An Evaluative Review, Sec. I, Appendix B.

[2] John E. Coulson, "Automation, Cybernetics, and Education." (Paper presented at the Conference on Cybernetics in the School, held at Vancouver, British Columbia, on February 20, 1965), pp. 3 and 5. See also, James L. Rogers, "Current Problems in CAI," Datamation, September, 1968, p. 28.

computer managed; problem solving, drill and practice, dialogue and tutorial; counseling; library retrieval; information center; and simulation).[3]

CAI in the Civilian World

Only a few representative CAI projects will be covered--merely to indicate the broad range of CAI applications and some of the study results obtained.

Industrial Uses

At this time there appear to be no CAI efforts underway in the industrial community of this Nation, outside of computer hardware or software firms. It is recognized that the previous statement warrants support. None of the literary indexes researched or papers reviewed in the conduct of this thesis presentation discussed any industrial CAI applications. In addition, none of the computer hardware or software representatives in the Washington, D.C. area which were contacted offered evidence of any such industrial programs. To further satisfy the validity of the statement that no industrial CAI programs are generally known to be in existence, contact was made with the National Security Industrial Association (NSIA). Mr. Norman E. Rogers,

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[3] Commission on Industrial Technology, A Report by the Commission, To Improve Learning: An Evaluation of Industrial Technology, (New York: R. R. Bowker Company, 1970), Volume I, pp. 199-208. See also Joseph B. Margolin and Marion R. Misch, Computers in the Classroom, (New York: Spartan Books, 1970), pp. 80-85. See also Zinn, An Evaluative Review, Sec. I-3, pp. 13-19.

Committee Executive for NSIA, offered the services of his office in contacting organizations about this statement. Mr. Rogers reported that although there are CAI investigatory studies in progress by such major non-computer manufacturing industries as the American Telephone and Telegraph Corporation, there are at present no known industrial tutorial CAI programs.[4] In fact, the only industrial firm known to be actually utilizing CAI is the Lufthansa German Airlines. That firm is using a UNIVAC based program to teach procedures to new reservations and scheduling clerks in Germany.[5] The magazine, Datamation, has indicated that as far as industrial training is concerned, American industry will not utilize CAI unless there is a clear cut advantage to it over other media.[6] This advantage is not now evident at low annual instructional volume rates.

That leaves the bulk of the civilian CAI effort to the field of education--as Zinn lists only IBM as being involved in CAI training, and that is for IBM-oriented training only.[7]

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[4] Norman E. Rogers, Committee Executive, National Security Industrial Association, Washington, D.C. Telephone interviews during November, 1971 and January, 1972.

[5] John J. Giesey, National Account Representative, UNIVAC Division of Sperry Rand, Washington, D.C. Personal interview held during November, 1971.

[6] "CAI Curriculum and Instruction Strategies," Datamation, December, 1967, p. 92.

[7] Zinn, An Evaluative Review, Sec. I, Appendix B, pp. 37-39.

Educational Institution Uses

It seems most appropriate to introduce this segment of the chapter with some comments which indicate the proximity of the immense impact CAI is going to make in education.

This can best be shown by work done at the University of Pennsylvania. Dr. John G. Brainerd, Director of that University's Moore School of Electrical Engineering, views the computer not only as a educational tool in its own right but also has creatively pushed the educational media interdisciplinary world one step beyond "conventional" CAI. Dr. Moore is helping to develop an integrated computer-communications based educational system in which the teacher at the Electrical Engineering School will be " . . .. an originator and curator of information [who will be] aided by automated preparation and selection [of] documents, audio visual films and slides, or convential television . . . ."[8] Others discuss this approach but Dr. Moore seems closest to a practical working educational complex involving an entire college. This integrated multi-media approach to an education system has been a major faculty effort for over 10 years and has now been expanded to include the possible presentation of full courses at locations away from the campus proper--at one's home, for example.[9]

But back to the here and now.

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[8] "Student Teacher and Machine," School and Society, January, 1970, pp. 4.

[9] Ibid., pp. 4-5.

Remaining for a time in Pennsylvania we will shift our attention to Pennsylvania State University. This University has developed a CAI school-on-wheels.[10] The initial study for this innovative approach to CAI training began in 1967. By 1970 the mobile CAI van was a fact. It is now on its 1971-72 "tour," offering a 3-credit hour course entitled Early Identification of Handicapped Children--a special education course which can be completed in less than 30 hours using CAI. The van can accomodate approximately 150 teachers during a typical six-to-eight-week tour period if the course is taken on a spare-time scheduled basis. On a 6-to-8-hour per day basis, study can be comfortably completed in three days with or without a supplementary text, according to Dr. Cartwright, who developed both the CAI course and text.

The efforts of the University of Illinois have been briefly touched upon earlier, however the extent of program development was not discussed. That school utilizes CAI for courses relating to at least 20 fields and has well over 100,000 student contact hours on their system. Design characteristics for the follow-on system (PLATO IV) include entire courses which will be taught completely by CAI; which will have up to 4,000 student terminals distributed over a broad geographic

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[10] Dr. G. Phillip Cartwright, Associate Professor and Director, Computer Assisted Remedial Education, College of Education, Pennsylvania State University, University Park, Personal interview held on December 23, 1971.

region; and which will hopefully utilize a newly designed low cost, high performance plasma display terminal for student use.[11]

Illinois' present system, PLATO III, is already sufficiently sophisticated that it incorporates a set of algorithms in a "judging routine" which permits, for example, a geometry student to draw a geometric shape on a graphic display in response to a question--but does not insist that the shape be totally exact, in any particular location, attitude or size.[12] Obviously this system has a very powerful language and subroutine set.

One indication of the effectiveness of CAI is shown by the results of a medical science course taught by the Illinois system. Twenty CAI students scored as well as their conventionally instructed control group counter-parts on a nationally administered test. The significance is that the CAI group spent from 33-50 per cent less time under instruction and showed greater subject retentivity than the conventionally instructed control group over a 26-week post-test period.[13] (The control group was randomly selected.)

There are other examples of uses of CAI in the medical education field--computers are used in medical schools not only

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[11] D. Alpert and D. L. Bitzer, "Advances in Computer-Based Education," Science, March 20, 1970, pp. 1585-1588.

[12] Ibid., p. 1584.

[13] Ibid., p. 1585.

for the retrieval of patient records and for test data analysis but also as instruction devices. No fewer than seven different CAI courses from various schools were available and discussed at a 1968 medical conference. The following is an example of a few titles from the summary of that conference:[14] "The Human Spinal Cord" (tutorial); "The Cardiovascular System" (drill and practice); "Sampling Theory" (tutorial and problem solving); "Resusciation in Anesthesia"; and "Crushed Chest Patients" (student research reporting and computer analysis for accuracy and implications response).

Florida State University has a Computer-Assisted Instruction Center which is sufficiently advanced that it has offered a 45 quarter-hour graduate credit course covering all aspects of computer-based, multi-media instruction at the college level. Follow-up questionnaires indicate that participants considered the course very valuable in their current administrative and teaching positions.[15] Florida State is involved primarily in CAI research--only a few projects will be mentioned here. One study was concerned with CAI simulation of laboratory experiments. Obvious benefits from simulation are the elimination of health hazards, equipment availability requirements are negated, and weather and physical space constraints are no

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[14] Proceedings of the Conference on the Use of Computers in Medical Education, (co-sponsored by the U.S. Department of Health Education and Welfare and the University of Oklahoma Medical Center, held at Oklahoma City, Oklahoma, April 4-6, 1968), p. 104.

[15] Zinn, An Evaluative Review, Sec. I, Appendix B, pp. 33-36.

longer training factors. CAI Center test data indicated no significant difference in test scores or times to complete laboratory simulated physics materials; however, lab hazards were avoided and lab equipment was not required, fewer instructors were needed and no set-up, take-down or clean-up times were required.[16] Two other Florida CAI Center experiments are of obvious interest. One was directed toward another purpose but final results also indicated that "functionally illiterate" adults may not even be able to cope with simple non-problem solving CAI programs developed at a basic reading skill level.[17] The obvious remedy is to ensure personnel have a basic reading skill before exposing them to the frustrations, embarrassment, and conflict of a verbal skill based program. Somewhat along these same lines, a later study concluded that the effects of an individual's trait development and inherent anxiety toward performance is very much the same in the CAI environment as is found in a traditional instruction environment for any particular individual.[18]

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[16] Darol Graham, Guenter Schwartz and Duncan Hansen, Multi-Media Simulation of Laboratory Experiments in a Basic Physics Lesson on Magnetism, (Florida State University, CAI Tech Center Memo No. 25, November 1, 1970), pp. 20-32.

[17] Francis Worth Scanland, An Investigation of the Relative Effectiveness of Two Methods of Instruction, Including CAI, as Techniques for Changing the Parental Attitudes of Negro Adults, (Florida State University, CAI Center Tech Memo. No. 13, July 15, 1970), pp. 36-39.

[18] Charles D. Spielberger; Harold F. O'Neil, Jr.; and Duncan N. Hansen, Anxiety, Drive Theory and CAI, (Florida State University, CAI Center Tech Memo. No. 14, September 15, 1970), pp. 52-63.

Stanford University, in an effort similar to Florida State's, is basically a CAI research-center effort in support of public education (as differentiated from being an operational curriculum support effort for the University, as is the Illinois system).[19] Its primary CAI work is in mathematics and language skills drill and practice.[20] Both military and civilian drill and instruction courses have repeatedly shown 20-30 per cent reductions in training times to prescribed levels of achievement and understanding, as has been pointed out earlier and will be iterated in the following pages.

There are many, many other minor and major applications of CAI programs in educational institutions, most of which are either research and development or short session (15-20 minute) courses. There are also on-going investigations in new methods of tackling old jobs--such as computer grading of essays;[21] but the information above is representative of the spectrum of civilian CAI.

CAI in the Military World

Air Force

The military services actually appear to have become involved with CAI before many people (perhaps themselves) were

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[19] Commission Report, To Improve Learning, Vol. I, p. 337.

[20] Margolin, Computers in the Classroom, p. 129. See also Zinn, An Evaluative Review, Sec. I-3, p. 13.

[21] Henry B. Slotnick and John V. Knapp, "Essay Grading by Computer: A Laboratory Phenomenon?" English Journal, Vol. 60, No. 1 (January, 1971), 75-80.

aware of what CAI was. This involvement was first in the form of the USAF on-the-job-training program via computer generated simulation for the Semi-Automatic Ground Environment System in 1955. This was subsequently followed by simulation of operations for North American Defense and most recently (1970) for Back-Up Interceptor Control systems.[22]

The USAF also has implemented a CAI course to instruct personnel in the use and maintenance of the Base Level Military Personnel System (BLMPS). This is a real-time personnel management system which is being phased into over 140 bases and will involve initial training of over 15,000 personnel specialists. The course appears to have been superbly engineered to permit complete integration of the training of personnel on the very system that generates the training requirement. Obviously, training costs for this course will be minimal--equipment expenses would have been incurred with or without the CAI approach to specialist training. Being taught on-site, literally hundreds of thousands of travel and per/diem dollars will be saved. The course will train both the computer operators and the personnel specialists who will use the BLMPS.[23] The Air Force also has some CAI materials for training on intelligence data handling systems and is developing an Advanced Instructional System for the interaction of CAI with other

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[22] First NSIA Seminar, ACT, p. XXIII-1.

[23] Second Regional Seminar of the NSIA, Application of Computers to Training, (held at U.S. Naval Training Center, San Diego, California, April 14, 1971), pp. 19-21.

training vehicles. It will be an interdisciplinary, multimedia computer based system.[24]

Navy

The U.S. Navy also got its CAI start in a simulation mode--in 1958 at the Naval War College at Newport, Rhode Island. The Navy War College device simulates major fleet operations to provide senior officers a combat tactics and strategy gaming exposure.[25] Since then the Navy has had considerable additional experience with CAI.

In 1966 the U.S. Naval Academy at Annapolis, Maryland, began utilizing CAI in the classroom. This academy is a four year, college degree conferring school for selected Naval officer candidates. Six CAI techniques have been used--tutorial, testing, drill, data reduction, problem solving and simulation. Courses in physics, chemistry, Russian, and operations analysis have been given by CAI.[26] Official written data to support the extent of effectiveness of this program is sparce. The Annapolis CAI test project was partially supported by the Office of Education and by 1970 was yielding evidence of its cost effectiveness to the extent that only slightly over half of the costs of CAI were borne by Navy Operations, vice Research, money.[27]

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[24] CAI "Shirtsleeve" Conference, Attachment I, pp. 18-19.

[25] First NSIA Seminar, ACT, p. XXV-4.

[26] Ibid., Supplement, pp. 65-68.

[27] C. W. Kennedy, Capt., USN, "CAI in the Navy," (unpublished briefing paper used at U.S. Navy Bureau of Personnel, December, 1970), pp. 9-10.

The CAI test program at Annapolis has been discontinued at this time and all original CAI team members have terminated full-time employment at Annapolis.[28] It is not fully evident to the author what the status of CAI at the Academy will be in the future. A study of both the educational and cost benefits of that program is now in progress.

At U.S. Naval Training Center in San Diego, California, a CAI course in Basic Alternating Current Theory is being taught. This course was developed by the Naval Personnel and Training Research Laboratory at San Diego. Data reported by that Station indicates that from 33 to 44 per cent of the hours required by convential techniques for certain course elements is saved when CAI is implemented. In addition, CAI students' grades are higher on both the standard school test and on a supplementary objectives-attainment-level test.[29]

The Navy has a very large multi-discipline technical training center at Memphis, Tennessee. By 1969, training personnel at that Station had successfully developed a modularized branching CAI program with "module" packages of instruction ranging from 15 minutes to two hours. An apparent high degree of instructional individualization has been attained and the scheduled Aviation Mechanical Fundamentals course has been

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[28] Rayburn A. Williams, Specialist for CAI and School Administration: Bureau of Naval Personnel, Arlington, Virginia, personal interview held during December, 1971.

[29] First NSIA Seminar, ACT, pp. VIII-3--5, and Williams, personal interview held in November, 1971.

reduced from four to three weeks. The success with this course lead to work on the Aviation Fundamentals Course which has been reduced from two weeks to one week. This CAI program is under development by the Research Laboratory at San Diego which expects to release full operational control of the programs to the local command in 1973 or 1974.[30]

There are several types of computer driven simulation models in the Navy, as in the other military services. These are frequently situation simulators which portray data on an appropriate read-out display device. There are usually ancilliary control mechanisms to counteract or at least permit one to react to the situation as it develops and changes.[31]

Marine Corps

The U.S. Marine Corps has had very little exposure to CAI (excluding computer-driven simulation devices). However, the Marine Corps has conducted a CAI feasibility study for one small segment of a radio fundamentals course in electronics trouble-shooting (requiring manipulative as well as cognitive skills). It should be stated that although this was only a one-week segment it was entirely taught by CAI and therefore represents a CAI course length which is considerably longer than the normal civilian courses. (Recall that, for example, Pennsylvania State's 3-hour credit course is designed for an

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[30] Ibid., pp. XVII-1--6.

[31] First and Second NSIA Seminar, ACT, at various pages throughout the documents.

intended maximum student time of 30 hours.) A great deal of care seems to have been taken by the Marine Corps School to avoid a Hawthorne effect during CAI evaluation and in the opinion of critical observers it must have been negligible.[32]

Post training and retention test results were very much in favor of CAI. At this point in time the Marine Corps is evaluating plans to teach four radio-electronics fundamentals courses by CAI at MCB, 29 Palms, California--to some extent contingent upon negotiation of lease-use rights via existing communications networks on an appropriate computer.[33] It is estimated that it will take approximately eight months to integrate CAI into the four courses. This will result in approximately 350 CAI hours in a combination tutorial-problem solving mode.[34]

The Marine Corps future CAI planning (excluding simulation) lies in two areas. The first area is the Marine Corps Amphibious Warfare School Extension Course. It is hoped that multi-media programs can be written and assembled at Quantico, Virginia, for reproduction and distribution to major outlying stations. The second effort is a tentative study proposal to

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[32] Blyth, C. W., LTCOL, USMC, letter discussing CAI testing and recommending procurement, April 1, 1971.

[33] Godfrey, Edwin J., LTCOL, USMC, Assistant Branch Head, Training and Education Branch, Headquarters, Marine Corps. Personal interviews held during November and December, 1971.

[34] W. G. Joslyn, General, USMC, "Economic Analysis of CAI for Marine Corps Communication and Electronics School," Memorandum by the Office of the Assistant Chief of Staff, G-3, Headquarters Marine Corps, October 29, 1971, p. III-7.

determine the applicability of CAI over the entire Marine Corps training establishment.[35]

Army

The U.S. Army has several on-going CAI programs. Since 1967 it has had a CAI system for Morse code instruction which reduced training times to desired goal achievement levels by 25 per cent.[36] In 1968 the Army started a CAI test program in Basic Electronics and by 1970 had approximately 78 hours of electronics-course subject matter being taught by CAI at its Signal Corps School at Fort Monmouth, New Jersey. The average savings in training times via CAI for initial instruction programs was 20 per cent and the school staff expressed its confidence in the effectiveness and versatility of CAI. It was a stated requirement; however, that at this Command, a qualified instructor always be the author and also be in the classroom during CAI training.[37] By the end of 1971 Fort Monmouth had become a significant user of CAI with a full four week program of instruction, and a total throughput of approximately 1,100 students who received from one to four weeks of CAI in Basic Electronics. It was stated that there was an average time

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[35] CAI "Shirtsleeve" Conference, Attachment I, page 6.

[36] First NSIA Seminar, ACT, pp. XV-1 and -3.

[37] Ibid., pp. VII-4--6.

savings of from 25 to 30 per cent over previous conventional instruction methods.[38]

At this time the Army's Fort Monmouth feasibility CAI test program is also shut-down ("also" referring to the Navy, Annapolis program). CAI efforts at Fort Monmouth have now shifted to further testing and CAI investigation using the PLATO system and one of the aforementioned plasma display devices (other terminals are also in use). An analysis team is reviewing previous CAI work results.[39]

CAI is also utilized at the Army Infantry Training School at Fort Benning, Georgia. That base has approximately 10 CAI infantry related courses and also reports 25 to 30 per cent training time reductions without any degradation in student output quality.[40] Simulation devices are extensively used for training in the Army at its Logistics Management Center, Fort Lee, Virginia. There are three complete logistic management courses which are essentially fully taught by CAI in a simulation mode.[41]

The future of CAI in the Army will be contingent to a great extent upon the report submitted by a top level analysis group now at Fort Monmouth studying the problems and effectiveness of the Basic Electronics CAI system (which saturated its

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[38] Craig A. Hagen, Major, U.S. Army, Operations Research Analyst, Management Informations System Directorate, U.S. Army Headquarters, Washington, D.C., Personal interviews held during December, 1971.

[39] Ibid.

[40] Ibid.

[41] First NSIA Seminar, ACT, p. X-1.

system hardware capabilities). One of their goals, if they validate that CAI is cost-effective, is to determine which courses taught by the Signal School could or should be taught by CAI, and the priority of conversion of subject areas to CAI within course structures. They are also tasked to define the system characteristics which could achieve the desired ends. There is little doubt that current state of the art hardware and software can be used in the analysis.[42]

The U.S. Army's most ambitious effort to extend the state of the art is called Project IMPACT (Instructional Model Prototypes Attainable in Computerized Teaching). This has been an on-going effort by the U.S. Army since 1968. The Human Research Resources Organization (HumRRO) of Alexandria, Virginia, (formerly of George Washington University), has the project study and development effort.

The HumRRO IMPACT task is, simply stated, to develop " . . . an effective, efficient, and economical computer-administered instruction system in a total system framework."[43]

Dr. Seidel, the Project Director, is very concerned about premature loading of a system into the Army training environment without insuring that it is capable of interacting in an almost limitless multi-media tutorial dialogue; and in proper response to each student's needs and capabilities at any given point in time. He calls this type of a model strategy

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[42] Hagen, Interview during December, 1971.

[43] Seidel, Review of Project Impact, p. 2.

an IDM--Instructional Decision Model.[44] This is a very ambitious undertaking but admittedly is the most appropriate next evolutionary step in the improvement of automated instruction--not only interdisciplinary with respect to the art and science of instruction, but also with respect to multi-media control.

Synopsis

This chapter was introduced with an indication of the expansiveness of the possible application techniques of instruction strategies possible with CAI (e.g., tutorial, drill and practice, etc). It then proceeded to show examples of CAI in the civilian and military worlds and touched briefly upon some of the more provocative possibilities being investigated. A few of these were: a 4,000 terminal PLATO System utilizing a new student display device; a program design incorporating computer-communications integration with a vast multi-media repository retrieval capability; a mobile CAI school; the use of a computer to aid in teaching manipulative maintenance skills; war game and logistics system simulation techniques; and HumRRO's hardware-software research package which is intended not only to be multi-media but also multi-sensitive to the known psychological understandings of human learning and educational strategies.

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[44] Ibid., pp. 3-9.

CHAPTER IV

CAI CONSIDERATIONS

Undoubtedly, by this time, one has mentally inquired: Why CAI? We have a world that has been learning for eons without computerized instruction. In 1965, Coulson indicated that the potential threat to wide spread use of automation in education would not be a problem of equipment limitations but would be one of our lack of adequate understanding about human factors--and about the effects of highly individualized man-machine knowledge interfaces.[1] Perhaps the best way to begin this chapter is with a discussion of some of the favorable and unfavorable aspects of CAI.

Objections and Praises

First, the objections to CAI will be discussed. Chapter II pointed out some problems the early teaching machine evolution encountered. CAI has also encountered problems. Many CAI programs are no more than programmed textbooks which have been rewritten by a programmer, manipulated through a computer, and regurgitated on a display device. Theodor Nelson seriously questions this approach to the misuse of the computer

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[1] Coulson, "Automation, Cybernetics and Education," p. 9.

and deplores those programs which are merely elaborate, expensive methods of controlling knowledge expansion. He also feels that forcing student interaction with the computer in a predetermined order of presentation, as many CAI programs do, is beneath the dignity of the mental and physical efforts required to develop such programs.[2] Many CAI programs are not beyond the state Larrick used to describe teaching machines, i.e., incapable of " . . . developing creativity and the urge to question and explore."[3]

Some educators feel that just because the campus has a computer and something called "CAI" exists, that *ipso facto*, automatic teaching is theirs for the taking without further expenditure of effort. Anyone even casually acquainted with computers knows this is impossible. Much of the problem lies at the very lack of ability or willingness on the part of educators to define their objectives adequately. They are reluctant to put their course objectives in terms of acceptable computer input strategies which will permit more than a notebook or outline type of non-instructionally creative data presentation.[4] Psychologist Robert Gerry and scientist James Rogers both warn potential users of CAI that the simple availability of hardware, regardless of its flexibility, is inadequate

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[2] Theodor H. Nelson, "No More Teacher's Dirty Looks," *Computer Decisions*, September, 1970, pp. 16-23, as referenced in *Data Processing Management*, December, 1970, pp. 5-6.

[3] Larrick, "Teaching Machines," p. 1652.

[4] Thomas R. Nee, "Educational Usages of the Computer," *The Clearing House*, September, 1971, pp. 63-64.

for any improvement in education--what is needed is an improvement in the knowledge of teaching and learning factors. A knowledge which can be integrated with the computers vast capacity to manipulate data and control peripheral devices in a method which will enhance the student's ability to learn--at the time and in the format that he as an individual heeds the information,[5] i.e., individualized instruction. Gerry also cautions that too frequently learning goals are not adequately translated into course objectives in terms which can be measured by the program.[6]

One other concern, not often discussed in CAI literature, but nevertheless a very real and appropriate concern, is that of the invasion of privacy. If details of a student's past educational progress are readily available and are open to all, does it mean that forever his future expectations for employment are contingent on yet another interpretation which can be made by the hiring organization?[7]

Most of the objections to the acceptance of CAI can be distilled into the following brief list, which is an updated summary of that prepared by Dr. Harold Mitzel:[8]

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[5] Rogers, "Current Problems in CAI," pp. 31-32. See also Robert Gerry and C. Victor Bunderson, "Preparing Educational Materials for Computer Assisted Instruction," (unpublished guidance paper used by the CAI laboratory, University of Texas, Austin, Texas, February 28, 1967), pp. 14-17.

[6] Gerry, "Preparing Materials for CAI," pp. 22-23.

[7] Margolin, Computers in the Classroom, p. 155.

[8] Harold E. Mitzel, "Five Barriers Hindering Computer Assisted Instruction, Administrative Management, June, 1968, pp. 45-46.

1. Educators do not know the proper computer/instructor mix of course material for any given subject or course.

2. System incompatibility is paramount, very few programs of different origin can be run on the same computer.

3. Differences of opinion exist concerning development--should an extremely versatile operating system for CAI be developed, then the courses written; or should courses be written which contain the strategies desired and then an operating system be designed around this requirement?

4. Educators and parents, as well as students have become accustomed to a "standard bill of fare" which frequently bases a student's grades on a teacher's perception of what an individual has learned, and it is usually relative to the achievements perceived for other students. CAI offers course mastery to every student coupled with individual objective, skill level achievement data.

5. A very exhaustive and expensive programming and testing effort is required for courses which go beyond simple drill and practice or associative learning, an "iceberg" analogy can be made. (At Penn State, sophisticated programs offering alternative-remedial procedures are usually used only to about 12-20 per cent of the total stored program for that topic for most students. Although, of course, different students use different elements of the program.)

Now for the brighter side of CAI potential. Because CAI is a method of individualizing instruction, the student controls the system and education can become challenging without being humiliating; and can be motivating without being peer-depriving.[9]

Dr. Silberman equates knowing with memory and transfer, and goes on to indicate that the ability to transfer is more important than the ability to merely memorize.[10] Transfer implies association and recognition that a problem or opportunity exists. Different students and different subjects require different teaching strategies, but our present school construction and organization methods are not conducive to enhancing our ability to capitalize on individual learning differences.[11] CAI has the potential to give every individual a private tutor; an analysis of teaching-learning response inconsistencies; and a call for human help when resolution is beyond the patient, but inhuman electro-mechanical, man-machine interaction. With CAI, the teacher can once again become something beyond a drill master--but the biggest single problem is reforming the teacher, not the curriculum methodology.[12] This problem is also discussed by Dr. Margolin and Ms. Misch--they contend that part of the reason for the failure to advance the

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[9] Nelson, "No More Teacher's Dirty Looks," pp. 5-6.

[10] Charles E. Silberman, "Technology is Knocking at the Schoolhouse Door," Fortune, August, 1966, pp. 203-04.

[11] Ibid., p. 205.

[12] Ibid., pp. 124 and 198-99.

model of individualized instruction and analysis may well be due to self-imposed current limitations in teachers' practices.[13]

Casual attention to today's news bears out the fact that we no longer have the teacher shortage of the late 1950-early 1960's. In fact Diemut Heller points out much of the present objection to CAI is that in an already overstaffed public school system, personnel are more concerned about retention of their positions than they are concerned about a possible lowering of teaching standards.[14] Yet there is evidence that CAI enables the human evaluator to be an even more integral part of instruction. He can analyze each individual's performance completely through the learning cycle and right up to the specific training objective success or failure.[15] An advantage inherent to the programmed text and the teaching machine became even more obvious in CAI because the: " . . . student always knew where he stood, without waiting . . . ."[16]

With respect to CAI and lower IQ groups, Ms. Heller cites several authorities who have study results which indicate that these individuals fare scholastically much better with CAI than with conventional instruction.[17] (However, the caveat

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[13] Margolin, Computers in the Classroom, pp. 298-299.

[14] Heller, "Technology in Education," p. 7-8.

[15] Ford, "CAI for Navy Enlisted Training," p. 3. See also Hall, "CAI: Problems and Performance," pp. 629-30. See also Butler, "CAI in New York City," pp. 86-87.

[16] Skinner, "Teaching Machines," p. 976.

[17] Heller, "Technology in Education," p. 7.

presented in Chapter III concerning the Florida State studies regarding literacy should be kept in mind.)

The computer will not harm education if it is properly used, and it most likely will not be permitted to be improperly used in American educational institutions. Proper teacher orientation about CAI is essential--it will permit the instructor to develop a more creative, genuine interest in the student.[18] At any rate, CAI will probably not ever occupy more than 20-30 per cent of a student's total class time.[19] The fear of total non-human instructional orientation therefore appears unfounded.

Another not so small beneficial consideration of computers in education is the potential expansion of the availability of entire libraries and research files to every school and facility with a computer and communications link.[20]

Chapter III gave many references to the time saved by CAI over conventional instruction--usually 20-30 per cent of the conventional course length hours are saved. This savings can not be ignored.

Achievement

Very little has been written which will support statements relative to increased comprehension rates which may accure

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[18] Bruce L. Hicks, "Will the Computer Kill Education?" Education Digest, September, 1970, pp. 10-12.

[19] Patrick Suppes, "The Teacher and Computer-Assisted Instruction," National Educational Association Journal, (February, 1967), p. 17.

[20] Stephan J. Knezevich, "The Administrator and EDP," National Educational Association Journal, (February, 1967), p. 19.

to students who use CAI. As indicated at various places in Chapter III, most institutions have simply stated that there was no degradation in learning achievement by students taught via CAI. Both the Navy and the Marine Corps, however, have positively indicated superior learning achievements and have data to support their statements.

The Navy's results showed CAI scores of from 3-9 per cent better, on the same examination, than conventionally instructed control group student scores. It did not appear to researchers that the "standard" school examination actually tested for achievement in those objectives which the school's supervisors stated they were attempting to have mastered by the students. Accordingly, a supplemental test was developed and approved for use. It is most significant that on this course-objectives-oriented test, the CAI students scored from 14-23 per cent better than the control group. In every mental level category except one the CAI students did better on the objectives test than they did on the school examination. In both tests, however, CAI students consistently excelled over control group students at all mental levels.[21]

The Marine Corps test results of CAI Electronics Maintenance training also indicated that CAI trained students achieved

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[21] First NSIA Seminar, ACT, pp. VIII-3--6. (San Diego performed a two-way analysis of variance and results for the school and supplemental tests showed very high statistical significance, ($p < .001$ and $< .0001$, respectively), in favor of CAI students--p. VIII-3.

greater learning. CAI test group students corrected 87 per cent more instructor-induced faults which were inserted in their equipment while undergoing CAI training than did the non-CAI control groups (all groups worked an entire week). Eighty-eight per cent of the CAI students achieved a grade of 80 per cent or better on the school's examination for that week, while only 32 per cent of the non-CAI students scored that high. The final practical-test examination was one in repairing a series of electronic faults which were identical for all students but which became progressively more difficult to isolate and repair. It was the school's standard final practical examination for that week's instruction in the course. All CAI students successfully completed the 90 minute examination with 88 per cent of them doing so in less than 60 minutes. Only 60 per cent of the non-CAI students successfully completed the test.[22] (This author has first hand knowledge of the elaborate precautions taken to avoid a Hawthorne effect for this test.)

Both the examples cited above are fairly obvious evidence of the possible unintentional lack of both objectivity and individual attention possible with normal student-instructor ratio constraints imposed by traditional instruction techniques.

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[22] Edwin J. Godfrey, LTCOL, USMC. Assistant Branch Head, Training and Evaluation Branch, Assistant Chief of Staff G-3, Headquarters Marine Corps, Arlington, Virginia. Personal interview held during August, 1971. See also Blyth, letter dated April 1, 1971.

These achievements once more point up the powerful capability of the computer to individualize instruction and teach at a rate consistent with the learner's present capacity--"CAI programs are limited . . . only by the knowledge and insight of the program author."[23]

We will now shift to a different background-knowledge level classification of students, that is, the New York City English and mathematics drill and practice CAI being tested with elementary school children. The reported results give somewhat conflicting data. The first year's study indicated that: "CAI students earned higher gains in most grades with [statistically] significant differences . . . ."[24] The second year's report indicated that: fewer CAI lesson blocks were completed than was expected and there was no consistent pattern of improvement or degradation between CAI and non-CAI learners. There was an indication of CAI improvements for grade five students and of non-CAI improvements for grade six students.[25] These conclusions may be considered reinforcement for the Linda Carson quote which immediately preceeds this paragraph inasmuch as the second year's report also stated that: "The provision

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[23] Linda Carson, "Computer-Assisted Instruction--What It Can Do For Education," Educational Media, October, 1969, p. 14.

[24] Butler, "CAI in New York City: First Year," p. 87.

[25] Theodore Abramsom, et al. Evaluation of the New York City Computer Assisted Instruction Project in Elementary Arithmetic, Second Year, 1969-70, (New York: City University of New York, 1970), pp. 89-91.

in the CAI program for matching [instruction to] differences in pupil ability . . . was insufficient . . . ."[26] There is a stern warning evident here for the absolute requirement for well-prepared, well-tested programs. Two items are worth mentioning: New York City's programs are both commercially prepared packages; and a possibility exists that in this school system a Hawthorne effect probably did exist as alluded to by the study organization.[27] This fear of achievement and/or learning time compression being a Hawthorne effect is expressed by many, recently by Elizabeth Wilson, Director of Curriculum Development at Montgomery Public Schools, Maryland.[28] It should be emphasized that Ms. Wilson was speaking of drill and practice CAI observations.

Cost

There is an enormous amount of non-standardized, non-uniform, and therefore conflicting information concerning CAI costs.

Most data refers only to total CAI preparation costs per hour of instruction, not to total system operations costs--"Estimates range from $20,000 to $2,000,000 to produce 100 hours of adjunct material for a one-year course."[29] Duncan Hansen,

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[26] Ibid., p. 89.

[27] Ibid., p. 90.

[28] Margolin, Computers in the Classroom, p. 253.

[29] Zinn, An Evaluative Review, Sec. I-3, p. 9.

as reported by Zinn, also indicates preparation cost data no lower than $194 per hour for a 180 hour course.[30] Part of the data problem is that there are very few really long term CAI projects upon which one can substantially rely for cost information.[31] (A 1968 ARIES Corporation report did show conventional instruction costs per student hour as $.36 for Elementary/Secondary Schools and $2.76 for higher level educational institutions.)[32]

It may be recalled from Chapter II that the University of Illinois has had an on-going CAI effort since 1959.[33] It is granted that since 1959 a myriad of CAI improvements in techniques, hardware and software have evolved, but CAI personnel at that school have recently released estimates of their present PLATO III and projected PLATO IV systems. (The full PLATO IV concept is not operational at this time.) Authors Alpert and Bitzer have made estimates for PLATO III using current off-the-shelf terminal hardware with a third-generation computer. They indicate that education costs could be approximately $1.90 per student contact hour with 50 terminals in use, including software costs. Software costs were estimated at

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[30] Ibid., Sec. II-2, p. 13.

[31] P. K. O'Sullivan, Forest Service Research Report: Computer Assisted Instruction, 1968-73, (Report by the ARIES Corporation for the U.S. Department of Agriculture, Washington, D.C., June, 1968), p. 36.

[32] Ibid., p. 37.

[33] Alpert, "Advances in Computer-based Education," p. 1582.

from $400-$800 per hour for material preparation (inclusive of author's salary and supportive services--e.g., photographic, secretarial, computer trial and de-bug time, etc.).[34] Looking at averages, this could mean as little as $8.40 for preparation costs for a 35 hour course if 500 students per year took the course for each of five years.[35] These men have also made estimates for follow-on PLATO IV system costs incorporating a large third-generation computer and 4,096 remotely located plasma display terminal devices. Assuming 2,000 student contact hours per year, costs are estimated at less than $.40 per student contact hour of instruction, inclusive of all costs.[36]

First year costs for the CAI program in New York were reported at $3.73 per hour of instruction, inclusive of all costs and second year costs were estimated to be $3.17.[37]

Sustained high annual student throughput is an obvious key to lowering CAI costs. The Navy already estimates annual savings of 707 man years from instructor and student-training time reductions. This savings accrues from the elimination of just one week of training from each of two courses offered in their Memphis programs. The reductions were possible because

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[34] Ibid., p. 1586-1587.

[35] Average Cost = $600; $600÷(5x500) = $.24; $.24x35 = $8.40.

[36] Alpert, "Advances in Computer-based Education," pp. 1588-1589.

[37] Butler, "CAI in New York City," p. 86.

of the more rapid throughput possible with individualized CAI training. After all costs for CAI support are deducted, annual net savings are still over $2,000,000.[38]

The Marine Corps has prepared an exhaustive CAI cost-benefit analysis estimate. This analysis indicates that substitution of a combination CAI-lecture program for the present techniques will yield an annual course savings of over $447,000. The data is based on 1972-1973 student input estimates which include appropriate reductions in numbers for peacetime manpower levels. The savings accrue from the integration of CAI into just four courses of electronics study and included all CAI costs and anticipated instructor and student-training hours savings.[39]

While the annual saving is not so impressive as the Navy's, it is again mentioned that the student throughput is a prime factor in total savings, and that these projected savings can not be considered insignificant by normal standards.

Major Craig A. Hagan, an Army systems analyst, conducted a CAI study over an approximate three month time frame. This study culminated in the preparation of a most comprehensive, but unofficial and unpublished, overview of CAI. Major Hagan assumed a system using a centralized computer in a regional training

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[38] First NSIA Seminar, ACT, pp. XVII-5--6.

[39] W. G. Joslyn, General, USMC, "Economic Analysis of CAI for Marine Corps Communication and Electronics School." (Memorandum by the Office of the Assistant Chief of Staff, G-3, Headquarters, USMC, October 29, 1971), pp. III-9.

concept and reliant on present day data transmission modes. Student throughput was consistent with current estimates. He has also assumed an off-the-shelf computer system capable of handling 4,000 terminals (2,000 of which may be remoted from 100-150 miles) with a system inquiry rate of 2,000 requests per second and a response time of one-tenth of a second or less. All hardware costs were computed using current market prices. Software requirements were considered at 180 hours of preparation time for each hour of CAI material developed. (It was determined that if this development were to be done by a Civil Service employee at current rates, this would approximate $1,098 per hour. Recall that Zinn estimated preparation costs of from $200-$2,000 per hour.) For planning purposes, it was estimated that 500 hours of CAI course work would be considered. Using this approach, Hagan's results indicated a $.55 per student hour cost of CAI-only related costs based on system use for only eight hours per day on a 22 day per month basis. (The conservatism of the analysis is evident in that this is an increase in per hour costs of over 33 per cent of the PLATO IV system estimates.) Because he is aware that not every course of instruction can be practically taught by CAI (his apt example was physical training), he assumed only a 30 per cent instructor and overhead reduction in courses converted to CAI. Hagan still arrived at a cost savings in excess of $1.50 per hour compared

to what the Army is currently spending on training in its schools.[40] This study was one of the things which prompted a headquarters directed analysis group which is now at Fort Monmouth to substantiate or reject CAI cost and configuration data.[41]

It should be pointed out that Major Hagan's CAI system request rate of 2,000 inquiries per second has built into it a safety factor of two. If only 1,000 requests per second is experienced (which would be consistent with PLATO system data based on 70 million requests), there are four hours of computer time available during an eight hour student contact day; plus, of course, the 16 hours not used for training every 24 hour day.[42].

It is apparent that cost estimates for CAI have been very long in arriving. In 1968 the ARIES Corporation, which was hired to investigate CAI, found only one analysis of cost upon which they would rely (prepared by Kopstein and Seidel). Those CAI cost estimates ranged from $2.00-$3.73 per hour for public schools.[43] Examples given above show clearly the

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[40] Major Craig A. Hagan, "Computer Assisted Instruction (CAI): An Overview," (unpublished paper prepared for the Director, Management Information's Systems Directorate, U.S. Army Headquarters, Washington, D.C., September, 1971), pp. 17-29, Passim.

[41] Major Craig A. Hagan, Operations Research Analyst, Office of the Assistant Vice Chief of Staff, U.S. Army Headquarters, Washington, D.C. Interview held during December, 1971.

[42] Hagan, "CAI: An Overview," p. 29.

[43] O'Sullivan, Forest Service Report, pp. 36-67.

decreased costs of CAI and the increased use of CAI cost estimation methodologies. They indicate that CAI can now be cost-effective for some applications. Those studies also seem to show that CAI has not yet forced changes in traditional school administration techniques.

Hardware

Fortunately CAI systems do not require any peculiar hardware research efforts to function: Present computer hardware capability is so powerful and on-line storage capacities are so vast that they do not impose limitations on any known CAI application seriously conceived today. The CAI limitations are of language and perhaps most importantly, psychological and behavioral teaching strategy constraints; not of hardware computational, manipulative or retrieval constraints. (Much of this is reflected in the first section of this chapter because of that fact--that the problem is not one of hardware.) This is not to say that an improper or inefficient analysis might not result in accepting a system which may be inadequate for the CAI task demanded of it.

The primary reason that specialized hardware is not demanded for CAI is because of developments made for the business and scientific communities. They have already provided the incentive to manufacturers for development of those features

which are also essential for economic utilization of computers in an instructional role. A few of these features will be discussed.

Remote inquiry capability is an obvious requirement for widespread economical CAI implementation. Examples of contemplated systems having up to 4,000 remotely located terminals have been discussed in this chapter. These systems can use off-the-shelf hardware already developed for non-educational institution users. Remote inquiry capabilities for an extensive CAI system immediately presents the likelihood that time-sharing and multi-programming operational modes are highly desirable. These capabilities have also been previously developed for industrial and military computer users. The advances which have been made in multiplexing and message switching techniques also become spin-off advantages for CAI by permitting long distance regional transmission capabilities without increasing line construction or microwave frequency band requirements.

Although this wind-fall of hardware refinements has greatly reduced what might have otherwise been CAI hardware development costs, some problems remain. For example a teletype terminal is hardly an adequate student terminal by itself, because of both the noise levels and the limited type-in and response printout rates. Cathode Ray Tube (CRT) devices which can augument the keyboard (perhaps also permitting use of a light pen) greatly alleviate the noise and rate problems but

may set up conditions which are annoying and tiring due to flickering of the letters or figures presented on the scope face.

As multi-media approaches to CAI continue to be developed, such as is being done at Penn State, greater demands will be placed on the student terminal.[44] Current multi-media, multi-response selection devices almost approach a "Rube Goldberg" state, except of course that learning is a serious matter and they are the best devices available. The mobile CAI van which the author visited, (discussed in Chapter III) has a vast array of stimulus-response devices at the student terminal. These include: Keyboard, CRT, auxiliary image projector (controlled by the computer but responsive to the user), light-pen, audio signaling, flashing light signals, and a foot pressure-plate optional "proceed" signal. All this is in a very well designed, easily used, highly visible package. (In fact 16 such terminals can accompany the computer and storage devices in the expanding, mobile van.) However, if the multi-media terminal is ever going to move into the home it will probably have to be more compact and visually acceptable.

The plasma display device, also first mentioned in Chapter III, is a major student terminal research effort. It is being developed and tested at the University of Illinois. As its use and name somewhat infer, the display projection is

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[44] "Student, Teacher and Machine," p. 4-5.

generated from a gas-fitted glass container with transparent electrodes. A few words concerning this display are in order. The device is currently in a prototype stage and will be marketed under the trade name "Digivue." It will be compact (approximately 10x10x20 inches); will be capable of receiving and transmitting information in a digital format (enabling up to 1,000 student stations on a single educational-TV channel); and is estimated to cost approximately $1,800 (exclusive of an optional random-access audio system for vocal recording of local messages). Display will be via the plasma panel media and will be flicker free. The device will also be capable of self-generation of image projections.[45]

One of the significant hardware decisions which will have to be made is whether a single central computing facility is more appropriate than several decentralized (perhaps specialized) CAI computer locations. Florida State has issued a report which presents the thesis that centralized systems with a powerful language are preferable. The report authors feel that due to the staffing and maintenance requirements of computer systems the use of a multiplicity of computers may well prove to be economically unsound.[46] It should be mentioned, however, that Dr. Seidel views decisions concerning centralization

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[45] D. Alpert and D. L. Bitzer, "Advances in Computer-Based Education, Science, March 20, 1970, pp. 1585-1588.

[46] Henry T. Lippert and Edward V. Harris, APL: An Alternative to the Multi-Language Environment for Education, (Florida State University Systems Memo No. 4, August 15, 1970), pp. 2-4.

or decentralization of computational powers as functions of a trilogy of cost, complexity, and frequency. That is to say, frequent, complex decisions and tutorial strategies will probably require the capacity of a large central computer. An on-site mini-computer may prove cost-effective for problems of intermediate complexity. And he feels that terminal devices can have built-in simple internal computational capabilities.[47] (This is of course a rational declaration but it remains to be proven to be effectively capable of being implemented. It may be more expensive to develop prototype models and to study the problem to the last nickel than to pay data communications transmission costs.)

The term, "interactive" has sometimes been used to define both hardware and software capabilities. It seems more appropriate to use that term to define a specific interrelated man-machine response sequence. Such a sequence exists when a program design enables computer-generated terminal information to a user on the basis of the quality of the user's response to previous information presentations.[48] It is really therefore more than just a hardware or software capability. It is dependent on both, but has most operational reliance contingent upon

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[47] Seidel, "Review of Project IMPACT," pp. 19-20.

[48] Samuel L. Feingold, "PLANIT--A Language for CAI," Datamation, September, 1968, p. 41. Also discussed with Dr. Charles H. Frye, Director, Division of Research and Development Resources, Department of Health Education and Welfare, Washington, D.C. during January, 1972.

the program software, without which interactive response can not be initiated.

Software

It is rather obvious from the statements made in Chapters II and III that the software world of CAI is explosive. There are over 40 different languages at present.

Dr. Frye, now with the Department of Health Education and Welfare has classified languages into four major categories;[49] conventional compiler; adapted conventional compiler; interactive computing and display; and specially devised instructional author-languages. A brief discussion of these categories and the language capabilities follows.[50]

The "conventional" category includes languages such as COBOL and FORTRAN; both require an experienced programmer for efficient coding. These languages were not developed for CAI and although it is possible to write CAI programs in them, it is very difficult to do so.

The "adapted conventional" is, as its classification implies, an adaptation of a base language--CATO and FOIL are adaptations of the base language, FORTRAN. These languages are simplier than their base languages but still require programming experience for efficient use. Both CATO and FOIL extend the power of FORTRAN for the user by the technique of

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[49] Charles H. Frye, "CAI Languages: Capabilities and Applications," Datamation, September, 1968, p. 34.

[50] Ibid., pp. 35-36.

prewriting very explicit FORTRAN subroutines which act upon the CAI program via the FORTRAN compiler during program execution. Special routine identifiers written in CATO or FOIL are translated into specific FORTRAN subroutine calls.[51] For example, an adapted conventional instruction to check for an answer "match" could activate a subroutine which would result in a match check sequence and would define the next action.[52] The basic programming language is FORTRAN but FORTRAN has no such primary instruction label.

The "interactive computing and display" languages were developed to support the student-user by extending his ability to solve problems. They usually provide great deal of computing power but are not normally efficient for record keeping, session termination and re-start, or instructional sequence; but they can be learned in a few hours. Examples include, APL and BASIC; both languages are not only easier to learn than those listed earlier but they also diagnose and report errors to the user as they are encountered. Both APL and BASIC are primary languages, that is, they do not rely on a separate base language as do CATO and FOIL. These languages were developed to enhance user-service requirements in an interactive operational mode.

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[51] Dr. Charles H. Frye, Director, Division of Research and Development Resources, Department of Health Education and Welfare, Washington, D.C. Telephone interview during January, 1972.

[52] Paul Tenczar, Research Associate, Computer Based Research Laboratory, University of Illinois, Urbana, Illinois. Telephone interview during January, 1972.

(By interactive it is meant that the computer and program systems are designed to permit real time response interaction between the data files, finalized computations and the user.) Because of their basic user-service design these languages are primarily user tools rather than student monitors or course progress recorders. Either of these languages may be viewed as scratch-pad tools in that, as a rule, once the users problem is solved, retention of the logic and technique of solution for his problem is probably not desired.[53] (As would not be true of say, a FORTRAN user's program for a repetitive type job; however, some CAI course programs are run using APL and BASIC.)[54] These languages do not usually permit a display any more complicated than can be easily presented on a typewriter terminal.

The "specially devised instructional author-languages" generally have a capacity for monitoring performance and record-keeping, and have capabilities for building and administering instructional sequences. These languages will automatically format output messages which may aid the course author in developing his lesson strategy. ICU/PLANIT, TUTOR and COURSEWRITER are examples of this class of language. They are the easiest languages discussed to learn.[55] Because ICU/PLANIT is

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[53] Frye, personal interview. See also Frye, "CAI Languages," p. 35. See also Lippert, APL, p. 16.

[54] Tenczar, interview during January, 1972.

[55] Frye, "CAI Languages," p. 35.

the newest and is representative of the most powerful CAI author-language types, more space will be devoted to it.

These author-languages are not dependent on any other root language as far as the program author is concerned although they may use another language as a means of implementing the programs on a machine. For example, PLANIT may be viewed as a separate isolated language in a CAI operating system; however, to make PLANIT more machine independent its present form began with a pure FORTRAN base. It is now a meta-FORTRAN language built upon American Standards Association FORTRAN IV elements which were determined to have machine and operating system independent features (e.g., DO, GO, one dimensional arrays, and some library functions). This basic language was then expanded upon to use efficient machine transferable coding features needed for CAI, such as appropriate author and student assisting subroutines. The present PLANIT language has very powerful author-assist and calculation modes and may actually be called a CAI language system. According to David C. Aaronson, of SDC--PLANIT developers, one of the most important features added was the ability to write variables that could be converted to literal constants prior to ultimate compiling. This feature insures that data values prescribed as variables in the original code, for example the dimension for an array, would also be used in future programmed checks on that array. Aaronson indicates that one of the major obstacles to machine independence is that

of insuring that the program can agree with the machine imposed data format rearrangement requirements--the ICU/PLANIT system overcomes this: " . . . by specifying both the program and data formats in terms of the same set of variables."[56] The addition of these language changes and coding features is what prompts Aaronson to also call the PLANIT language a meta/language, or at least meta/FORTRAN.

Unlike CATO and FOIL, the course author writes his program in a PLANIT language, not in FORTRAN. This author-language is referred to as ICU/PLANIT, Instructor's Computer Utility/ Programming LANguage for Interactive Teaching. The ICU/PLANIT system is not only interactive but is also interpretive.[57] The interpretive feature may well spell its demise as a powerful system for CAI applications requiring simultaneous interaction with several terminals which demand highly computational procedures. It remains to be seen whether or not present day machine speeds will over-ride the inefficiencies of PLANIT's interpretive routine. COURSEWRITER also provides a very good highly interactive CAI system but it suffers severely from a lack of computational capabilities (this is because it was not even designed with any significant computational capabilities),

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[56] David C. Aaronson, "ICU/PLANIT: The All-Purpose Machine-Transferable CAI System," (paper presented at the Institute of Technical and Industrial Communication, Colorado State University, Fort Collins, Colorado on July 20, 1971), pp. 3--5 amd 9-10.

[57] Ibid., pp. 3 and 10-16.

and is not machine independent.[58] TUTOR, the University of Illinois' PLATO system language, is not only highly interactive, but has been designed with extensive computational capabilities, and unlike PLANIT, TUTOR is not interpretive.[59] TUTOR, however, has the unfortunate handicap of not being machine-independent and therefore its present programs will not run on any system other than those with hardware characteristics of the PLATO configuration.

All of the languages discussed to this point have a branching capability which can be based on a student's response, they can all therefore, be used for CAI. The choice and differences lie in the ability of each category to do the instructional job desired. At the very least, the more tutorial and dialogue-oriented the material must be, the more powerful in terms of external simplicity and automatic internal selectivity the language must be. The extensive work done at the University of Illinois has been previously mentioned. As one indication of the state of their CAI software capability, Karl Zinn has written, "A PLATO tutorial logic provides the most simple and convenient 'language' I have seen . . . ."[60] (Author's note--the ICU/PLANIT system had not been demonstrated at this time.) More recently through, Dr. Seidel has reported development of

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[58] Frye, "CAI Languages," p. 44. Also validated during the interview with Tenczar, referenced earlier.

[59] Tenczar, interview during January, 1972.

[60] Karl L. Zinn, "Instructional Programming Languages," Educational Technology, March, 1970, pp. 44.

a software product which can be learned by an unsophisticated author in 20 minutes and which will interface with a language such as TUTOR or COURSEWRITER.[61]

The computer can now simultaneously administer and evaluate different tests and programs to numerous students. Frederic Lord felt that once we had established an appropriate hierarchy of knowledge, it would also be a simple task for computer software to be developed which would enable the computer to actually "design" a different test for every individual and report its findings.[62] This apparently is more difficult to do than to say. As reported by Frei, there is still little agreement on what the capability of a CAI language should be. He goes on to identify why this is so, i.e., it is difficult to develop instruction strategies that properly prescribe what the program should do based on the user's current level of understanding.[63]

Listed earlier in this chapter were five barriers to effective CAI--one of those was the lack of compatability of software and hardware. An example of the inordinate expense involved in converting systems is indicated by a statement made that it could be extremely expensive (up to $500,000) to convert

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[61] Seidel, "Review of Project IMPACT," pp. 10-11.

[62] Frederic M. Lord, "Some Test Theory for Tailored Instruction," (paper presented at the Conference on Computer Based Instruction, Learning, Testing and Guidance, held at Austin, Texas, October 21-22, 1968), pp. 1 and 52.

[63] Hans-Peter Frei, "Study Trip to the USA," p. 7.

a CAI language from one hardware system to a competing firm's hardware.[64] It would be very, very difficult for any user to ignore this type of potential conversion cost; particularly if replacement hardware is desired or required for any of a number of reasons--just two of which might be saturation of the present system or withdrawal of the manufacturer from the market place. On the other hand, one paper has reported BASIC simultation in APL with only four hours of programming time being required.[65] Obviously a great deal of investigation and analysis is required before an organization commits itself to any software program.

The language capability and incompatibility problem will undoubtedly reign supreme until CAI users become more united than is now true. The decision as to what to buy (if a decision to buy at all is made) is fraught with problems. Military users are not generally permitted to buy products without competitive bidding offerings. There are well known efforts to circumvent the problem of being "locked-in" with a single computer supplier just because a program was initiated with him. The best example is the U.S. Government's insistance that all non-tactical general purpose computers be bid with a capability to accept COBOL. Perhaps something like this should be considered

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[64] "Computer Oriented Instruction/Computer-Oriented Program Instruction," a presentation by UNIVAC Corporation to the USMC at Headquarters, Marine Corps, Washington, D.C., on June 11, 1970.

[65] Lippert, APL, p. 16.

for CAI languages before the services are committed to large CAI systems. Another of the software problems is the manufacturers' reluctance (wisely) to develop CAI materials while educators cannot adequately define course objectives. Still another problem is that there is unsufficient copyright protection to insure CAI authors that illegal reproduction of developed CAI software without compensation would be prevented.[66]

There does not seem to be any great fear jointly expressed by the services over the software incompatibility problem for CAI. There was some concern voiced at the Joint Services CAI "Shirtsleeve" Session about the lack of software commonality, but it appears that an "institute" (pressure?) approach was not fully acceptable to conferee[67] (reasons were not given). This in spite of the fact that the subcommittee tasked with CAI research requirements had also reported to the joint group the need for integrated efforts: " . . . we have begun to move away from total dependence on the traditional individual scientist working apart from obvious real-world problems."[68]

Major Hagan feels that the software incompatibility problem is significant and that the military must soon address it.[69] "All of the services may already be victims of conversion

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[66] Commission on Industrial Technology, To Improve Learning, Vol. I, p. 337.

[67] CAI Shirtsleeve Session, Software Committee Report, pp. 4 and Sec. III, p. 1.

[68] Ibid., Sec. IV, p. 3.

[69] Hagan, "CAI: An Overview," p. 31.

incompatibility as they anticipate any future expansion of their current CAI Systems."[70] One possible software solution is an extension of current Human Resources Research Organization (HumRRO) and University of Illinois efforts to develop a Computer Assisted Authoring (CAA) capability. With this capability the machine leads the author through course development and generates its own object code for the CAI course. The author need only know CAI techniques well enough to comprehend the implications concerning the machine indicated alternatives he may choose.[71]

Support Personnel

As can be deduced from the earlier section on hardware, CAI equipment does not at this time demand peculiar support personnel skill identifications. Program maintenance for CAI requires the skills normally associated with a well managed, large, computer oriented organization. The Navy Training Research Laboratory identifies these skills as those held by:[72] computer analysts; systems maintenance-analysts; programmers; computer operators; terminal operators for remote, batch inputs; and card punch operators. The 1968 ARIES Corporation report lists essentially the same computer personnel-support skill requirements.[73]

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[70] Hagan, Interview held during December, 1971.

[71] Hagan, "CAI: An Overview," pp. 30-31.

[72] First NSIA Seminar, ACT, p. XVII-4-6.

[73] O'Sullivan, Forest Service Research Report, pp. 39-40.

Again, the problems in CAI implementation are not primarily of a hardware, but are of a software incompatibility and course-author-teaching strategy nature. There is a conscious effort on the part of many to insure that only subject experts write CAI programs. This is known to be true in the Marine Corps,[74] and (to present) in the Army.[75] The Navy's approach is more interdisciplinary as is evident by the program development of the Memphis courses through an integrated effort between regular school instructors and personnel research representatives.[76] The Air Force also uses an interdisciplinary approach to CAI course development.[77]

The obvious question is: Who should write CAI programs? Some educators feel as some Army and Marine Corps personnel do--that only subject experts are most qualified to write CAI programs.[78] Others, however, express the opinion that one person can not do it all. The HumRRO staff, for example, consists of personnel " . . . with expertise in behavioral science or research psychology, computer science, applied mathematics, electrical engineering and industrial programming."[79] Still another

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[74] Blyth, letter of April 1, 1971, and Godfrey, personal interview during April, 1971.

[75] First NSIA Seminar, ACT, p. VII-4.

[76] Ibid., p. XVII-4.

[77] Ibid., p. II-3-4.

[78] Ron Arnold and Ruth Penney, "Who Should Write CAI Curriculum?" Educational Technology, October, 1969, pp. 89.

[79] Seidel, "Review of Project IMPACT," p. 7.

example of an interdisciplinary approach is evidenced by the Xerox Educational Division as presented by Margolin and Misch. Each program staff consists of a subject matter expert, a behavioral analyst, a programmer, and test subjects who work under a program editor. Depending on the magnitude of the effort (e.g., multi-media) actors and/or a project administrator may be required. Xerox personnel are quick (and undoubtedly correct) to point out, that in their experience they have never found any one man who had all the skills and who could perform all the functions required to produce a satisfactory CAI program.[80]

The Navy, Air Force, HumRRO and Xerox approaches seem to indicate a fuller understanding and appreciation of what is required of an educational system. CAI does place a tremendous responsibility on course authors; although it is evident that in all cases such a staff is not absolutely necessary. Not all organizations with the potential to develop and use CAI can assemble such a staff; but then, all such organizations do not have a basic research concern--nor need they. Certainly this broad personnel base has not been used by all CAI course developers, yet some courses are obviously very effective in meeting their goals.

One of the Florida State studies spelled out an important consideration which must be constantly kept in mind by all CAI course development support personnel. That consideration is

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[80] Margolin, Computers in the Classroom, p. 102.

that programs must be written for the educational starting level of their intended audience. If one can not read well, he will not be able to cope with a program designed around an advanced vocabulary or grammatically complex presentation.[81]

Synopsis

This chapter has presented most of the major considerations which must be brought into focus whenever an organization has determined that it will shift from traditional to computer instructional techniques. An analysis of all those areas discussed is essential if the CAI educational system is to economically replace or even mesh properly with the present system. Every user has somewhat different requirements and constraints; it can not therefore be categorically said that merely by insuring that the areas presented here are considered that a sufficiently thorough investigation has been conducted. The field of CAI is very mobile and expanding; analysts would be sorely remiss if they did not use a systems approach to determine the feasibility of any projected system.

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[81] Scanland, "An Investigation of the Effectiveness of Two Methods, Including CAI," p. 38.

CHAPTER V

SUMMARY AND CONCLUSIONS

In the first chapter of this thesis its purpose was presented. That was, to answer the question: Has CAI sufficiently evolved to risk extensive commitment of military training funds for this type of instruction? The answer to that question--taken relatively--is yes. By "taken relatively," the author means that he feels the study indicates that CAI should be pursued by the military services. It also means that at this time a wholesale shift of training funds from present to CAI techniques would be in error. Many areas must be considered.

In traditional instructional methodology not everyone gets exposed to any one text book or only one idea pattern as developed by one individual for very extended time periods. This negates considerably the impact that any of these exposures has on the total population. CAI, however, has the potential (particularly if extensive program transportability and reproduction takes place) to structure learning achievement levels and ideological patterns in vast numbers of people almost before the resulting behaviorial direction can be measured. It seems that only a multi-disciplined approach is appropriate

and defensible for basic learning skills and societal conception formations. Success to date with CAI in the military however, seems to indicate that once an individual is fairly well educationally developed and has formed his own behavioral niche, extensive behaviorial interdisciplinary attention may not be necessary. This may be particularly true when the known end product desired is simple additional manipulative or control skill mastery--as is true of most first enlistment military jobs.

A conclusion in opposition to haste is further borne out by a fact which has persisted to evidence itself throughout this study. That fact is that CAI, after about 14 years of research and effort may now be about to make quantum jumps in multi-media power and language capabilities. Todays languages already far exceed the capabilities of earlier CAI languages. In addition, multi-media CAI approaches greatly broaden the potential of CAI to be educationally competitive or superior to many present military instructional techniques.

The trend of CAI expansion was first shown when the evolution of teaching machines was presented in Chapter II (in particular, the last few pages of the "delimited review" section). The "criteria" section therein indicated the potential pervasiveness of CAI applicability. Also listed in Chapter II were criteria which should be used when attempting to determine the potential a course of instruction may have for conversion to CAI based on the current stage of CAI evolution and availability.

Chapter III then went on to show both present day and proposed uses of CAI. In the "civilian" section of that chapter was obvious evidence of recent multi-media approaches to education. Results were sufficiently efficient to greatly reduce student throughput times in academically challenging courses. The "military" portion of that chapter also indicated that computer management of instruction was educationally advantageous and would be expanded upon.

Chapter IV dealt with the necessarily wide range of considerations which must underlie CAI implementation plans. The facts of continued evolutionary growth of CAI were again evident in the stated potential to integrate data from entire libraries of remotely located institutions and organizations for research. Chapter IV also indicated the expanding evolutionary state of CAI by citing examples of hardware and software efforts now under way. A few of the examples given will be reviewed. One such example was the plasma terminal device which will not only be a more compact, easier-to-use student terminal than now exists, but which also may enable multi-media CAI on a single student device. A truly mobile CAI school on wheels was shown to be in existance. The high speed and low computational costs of third generation computers over previous generations also enhances the CAI potential. This equipment makes possible much greater and more timely data manipulation, and decision variable possibilities. Software development was

also shown to have progressed considerably, and work is being done on even more powerful programs which can be used with practically no student or course author constraints. Topping all of this, Chapter IV made it abundantly clear that CAI is cost effective. Probably one of the most beneficial aspects of CAI is that most present hardware and software efforts have been an evolution in consonance with commercial computer capabilities. This has insured avoidance of the usual high costs associated with hardware research design efforts and limited production quantities.

In summation, this study has shown that CAI has proven to do as good or better a job as conventional techniques used at some service schools for some high student volume, fundamentals-type courses. One can draw no conclusion other than that CAI must be considered an alternative educational presentation technique for military training.

A Perceived Need

At this point the author is compelled to issue a caution concerning military CAI efforts.

The services have not yet formally joined forces with either the educational institutions or each other concerning CAI. This practically insures that there will be no course commonality or program compatibility nor any associated CAI multi-media standardization.

The military training establishment may well end up spending many times what the CAI development costs could be if they did form an educational partnership. In 1970, Dr. Seidel proposed a partnership of sorts--one between government, industry and education. He also stated that he felt this partnership, and education in general, would be enhanced by " . . . the establishment of a national center for research and development on innovation in educational systems."[1] (Seidel also indicated that this had been proposed some time earlier for the Department of the Navy but that the Department of Defense did not see fit to fund it.) This author fully supports the idea of a partnership as proposed by Seidel. But it is even more positive that regardless of what others do, the Armed Forces must join together in multi-media CAI development and implementation efforts.

CAI has been primitively proven, the services stand on the brink of a financial wind-fall greater than any single innovation that has ever come along to reduce training program costs. The Navy alone budgeted over $400 million dollars for training in 1970.[2] Recall that CAI enabled elimination of a week from each of two Navy courses and resulted in a net estimated $2 million annual savings. If in fact those Navy courses or other service courses can be designed in a modularized, use-what-you-need approach, the majority of the development costs

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[1] First NSIA Seminar, ACT, pp. XXX-12-13.

[2] Kennedy, "CAI in the Navy," p. 1.

associated with the base package would be practically negligible. (Particularly when spread over all four military training establishments. If we add the Coast Guard, and the Civil Service Commission it can be seen that for some common programs the development costs would be, relatively speaking, nil.) Of course, the programs must be written in a language which could be easily converted to present government general purpose computer requirements.

The military organization has an obligation to the public to prevent a debacle such as would have occurred if, for example, our independently developed tactical systems were incompatible in a joint-effort environment. Joint efforts must be considered in peace-time as well as in times of war.

This author does not know whether or not a sufficient degree of commonality of training exists between the services; but certainly within each service steps will be taken to insure intra-service compatibility of programs. It would be foolish not to investigate inter-service savings potentials possible with joint program development and interchangeability. If significant savings of public funds might accrue from such an effort, the services have an obligation to the public to effect such savings. If, on the other hand, no appreciable savings are likely, the documentation of the investigation may well silence public concern that training funds are not economically managed to the fullest extent possible.

GLOSSARY OF ACRONYMS USED

CAA - Computer Assisted Authority (a method whereby the CAI computer program assists the course author in the construction of his CAI course by insuring that he is aware of all available program strategies).

CAI - Computer Assisted Instruction (used in this study it refers to all computer applications in instructional roles).

Computer Languages and Developers

APL - IBM

BASIC - Dartmouth College

CATO - University of Illinois

COBOL - Conference on Data Systems Languages

COURSEWRITER - IBM

FOIL - University of Michigan

FORTRAN - IBM

ICU/PLANIT - SDC

PLANIT - SDC

TUTOR - University of Illinois

HumRRO - Human Resources Research Organization (a non-profit, non-political research and development group headquartered in Alexandria, Virginia).

IBM - International Business Machines Corporation (a computer research, design and manufacturing corporation headquartered in Armonk, New York).

IMPACT - Instructional Model Prototypes Attainable in Computerized Teaching (a HumRRO effort for the U.S. Army).

NSIA - National Security Industrial Association (a non-profit, non-political association of American industrial; research and educational organizations headquartered in Washington, D.C.).

PLATO - Programmed Logic for Automatic Teaching Machines (an on-going evolutionary study at the University of Illinois since 1959).

SDC - Systems Development Corporation (a computer software research and systems design corporation headquartered in Santa Monica, California).

TEXTRUCT - Techniques of Instruction in Technical Training (a HumRRO study Project for the Army).

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